Name____

Physics 111 Quiz #5, October 21, 2022

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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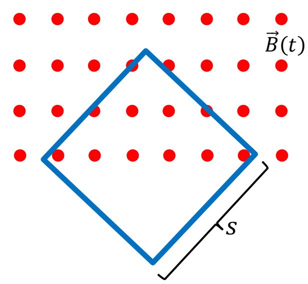
1. A $N = 300$ turn square loop of aluminum ($\rho = 2.65 \times 10^{-8}\Omega m$) wire lies in the plane of the page as shown, where the sides of the square have a length $s = 10cm$. The aluminum wire that the loop is made from has a diameter of $0.5mm$. What is the resistance of the aluminum wire loop?

$$R = \frac{\rho L}{A} = \frac{2.65\times10^{-8}\Omega m\times300\times4\times0.1m}{\pi(0.25\times10^{-3}m)^2} = 16.2\Omega$$



2. The wire (lying in the plane of the page) has a magnetic field pointing out through one-half of the square and the magnetic field is perpendicular to the plane of the page. The magnetic field varies in time according to $B(t) = 0.437 + 0.912t$, for t in seconds and B in Tesla, over a time interval $0 \ll t \ll 10$. What is the magnitude and direction of the induced current in the loop of aluminum wire?

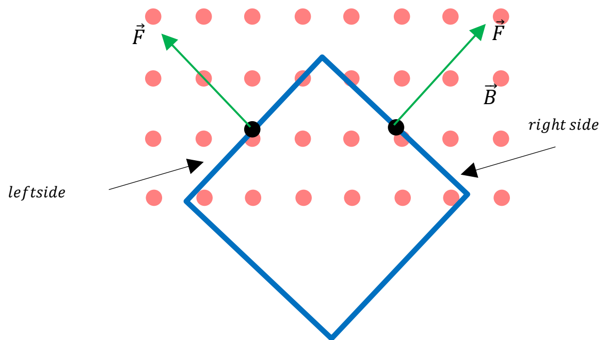
Since the magnetic flux through the loop is increasing with time (the magnetic field is increasing with time) the wire will create its own magnetic field to undo the increase in magnetic flux. Thus, the wire's magnetic field will point down into the plane of the page and this swill produce a *clockwise* current flow.

$$I = \frac{\varepsilon}{R} = \left|-\frac{NA\cos\theta}{R}\frac{\Delta B}{\Delta t}\right| = \left|\frac{300\times\frac{1}{2}\times(0.1m)^2\cos 0}{16.2\Omega}\times\frac{[(0.437+0.912\times10)-(0.437)]}{10s}\right| = 0.084A$$

3. Over the $10s$ interval of time, how much energy is dissipated as heat across the aluminum loop of wire?

$$P = \frac{\Delta U_e}{\Delta t} \rightarrow \Delta U_e = P\Delta t = I^2R\Delta t = (0.084A)^2 \times 16.2\Omega \times 10s = 1.15J$$

4. Suppose that you now make the magnetic field through the upper half of the aluminum wire loop be constant in time so that $B(t) = B$. Now you hold this page up in front of you such that the magnetic field is still perpendicular to the plane of the page but now points at your nose. If the wire loop is released from rest and allowed to fall out of the constant magnetic field, what are the directions of the magnetic force on the left and right sides of the wire loop? Draw these on the figure below at the locations indicated by the black dots on the wires. To earn full credit, you need to draw the forces (scaled appropriately to each other) and explain why they point the way you drew them.



As the wire lop falls out of the magnetic field, the magnetic flux through the loop of wire will decrease. To undo the decrease in magnetic flux we need the magnetic field produced by the loop of wire to point out of the page. This produces a counterclockwise current flow.

On the right side of the wire the current is flowing CCW, and the magnetic field points out of the page. The magnetic force must be perpendicular to the plane containing I and B. Thus, it must be perpendicular to the wire and by the RHR points up and to the right.

On the left side of the wire the current is flowing CCW, and the magnetic field points out of the page. The magnetic force must be perpendicular to the plane containing I and B. Thus, it must be perpendicular to the wire and by the RHR points up and to the left.

At any point along the left and right sides of the wire equidistant from say the top, the forces have equal magnitudes, and the vectors will have equal lengths.

5. Suppose that you have a light wave traveling through space and that you measure the magnetic field of the light to be $B_{max} = 7.5 \times 10^{-6} T$. What is the maximum electric field associated with the light wave?

$E_{max} = cB_{max} = 3 \times 10^8 \frac{m}{s} \times 7.5 \times 10^{-6} T = 2250 \frac{N}{C}$